INTERIM PROGRESS REPORT

SNOW MANAGEMENT AND MELTWATER ENHANCEMENT

PROJECT 3.2-3

CANADA/SASKATCHEWAN ECONOMIC & REGIONAL DEVELOPMENT ASSISTANCE (ERDA) FUND

December 21, 1988

Report Prepared

by

W. Nicholaichuk, NHRI, Saskatoon

D.M. Gray, University of Saskatchewan

B. McConkey, Agriculture Canada, Swift Current

NHRI Contribution No. 88091

PROGRESS

INTRODUCTION

The last INTERIM PROGRESS REPORT submitted in October, 1988 summarized activities of the experimental plans implemented in 1987-88. At the time of preparing this report, analysis of the 1987-88 results have not been completed, but will be reported in the ANNUAL PROGRESS REPORT to be submitted in February, 1989. This INTERIM PROGRESS REPORT will briefly summarize treatments, instrumentation and montoring programs at field sites installed in the fall of 1988.

ACTION PLAN

Except for Richlea, experiments at field sites located at Kerrobert, Saskatoon and Swift Current were implemented in the fall of 1988. Because of the crop failure at Richlea (D. Sutherland farm) during the 1988 growing season, hence the poor stand of stubble, the study of infiltration characteristics of cracked soils will be carried out at Saskatoon (Kernen Farm) during the 1988-89.

Details of the treatments, instrumentation and monitoring progress for each site are as follows:

1. Kernen Crop Development Farm (alternate to the D. Sutherland Farm at Richlea)

   Objectives:

   (1) To study the infiltration characteristics of severely-cracked soils,
   (2) To study the effects of subsoiling on meltwater infiltration,
   (3) To study the effects of "combined" snow management and subsoiling practices on meltwater infiltration enhancement and soil water augmentation,
   (4) To obtain information on the longevity of subsoiling treatment effects on infiltration, and
   (5) To study the effects on yield of subsoiling and snow management practices.

   Soil moisture and temperature monitoring sites are located in fallow, in cracked soil, and in two, 0.4 ha plots which had been subsoiled to a depth of approximately 50 cm on 90 cm spacings by a Hubee subsoiler in the fall of 1987. The field with cracked and subsoiled areas has a cover of uniform stubble.

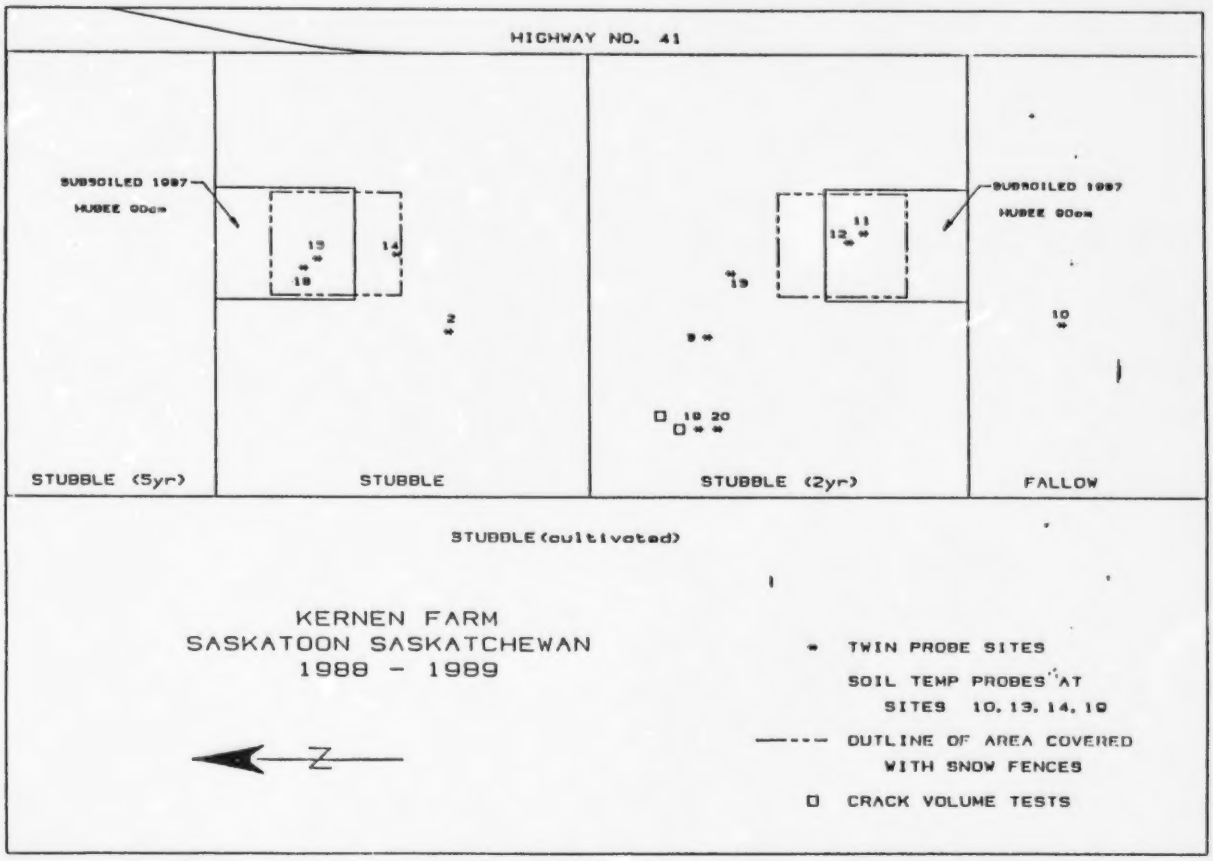

Figure 1. Schematic of locations of instrument sites; Kernen Farm, Saskatoon, 1988-89.

The number of sites in different land uses are: fallow - soil moisture (SM)-1; subsoiled areas - SM-4, soil temperature (ST)-1; uniform stubble (cracked) - SM-4, ST-1; and stubble (uncracked) - SM-2, ST-1 (see Fig. 1). Soil moisture installations permit measurement of moisture changes with the twin probe gamma meter (profiling resolution equal to 2 cm) to a depth of 1.2 m. The soil temperature probes provide real time measurements at depths of 2.5, 5, 10, 20, 40, 80, and 160 cm.

Other parameters being monitored are air temperature, precipitation, and snowcover depth and density. The sites are located approximately 8 km from the climate station operated by the Saskatchewan Research Council where radiation, wind speed, and humidity are observed.

Low snow fences (40 cm height) have been deployed as snow traps. These are set in rows approximately 15 m apart on two plots, each approximately 0.3 ha in size. These fenced areas overlap ripped and unripped areas of the stubble field (see Fig. 1). Soil moisture monitoring sites are located inside and outside the fence. Also, two of the four soil moisture sites in cracked soil are surrounded with a lower snow fence to ensure a range of snow accumulations and to allow estimates of "potential" increases in soil water by meltwater infiltration into cracked soils.

Two plots have been established to measure "effective" crack volumes. These consist of 4.0 2m2 areas which were isolated by trenching around their circumference to a depth of approximately 1.2 m, lining the trench with polyethylene sheet and carefully back-filling. Once the soil has frozen to a depth greater than 1.2 m, water will be applied to these plots and the amounts required to fill the voids used to index the effective crack volume. These values will be employed with the soil moisture data to derive an infiltration model for cracked soils.

2. Kerrobert (Ritz Reynold Farm)

Objectives:

(1) to study the effects of different subsoiling treatments on meltwater enhacement,

(2) To study the effects of 'combined' snow management and subsoiling practices on meltwater enhancement and soil water augmentation,

(3) To obtain information on; the longevity of the effects of a subsoiling treatment on infiltration, and the depth and spacing of different treatments for optimum soil water intake and distribution, and

(4) To study the effects of subsoiling and snow management pratices.

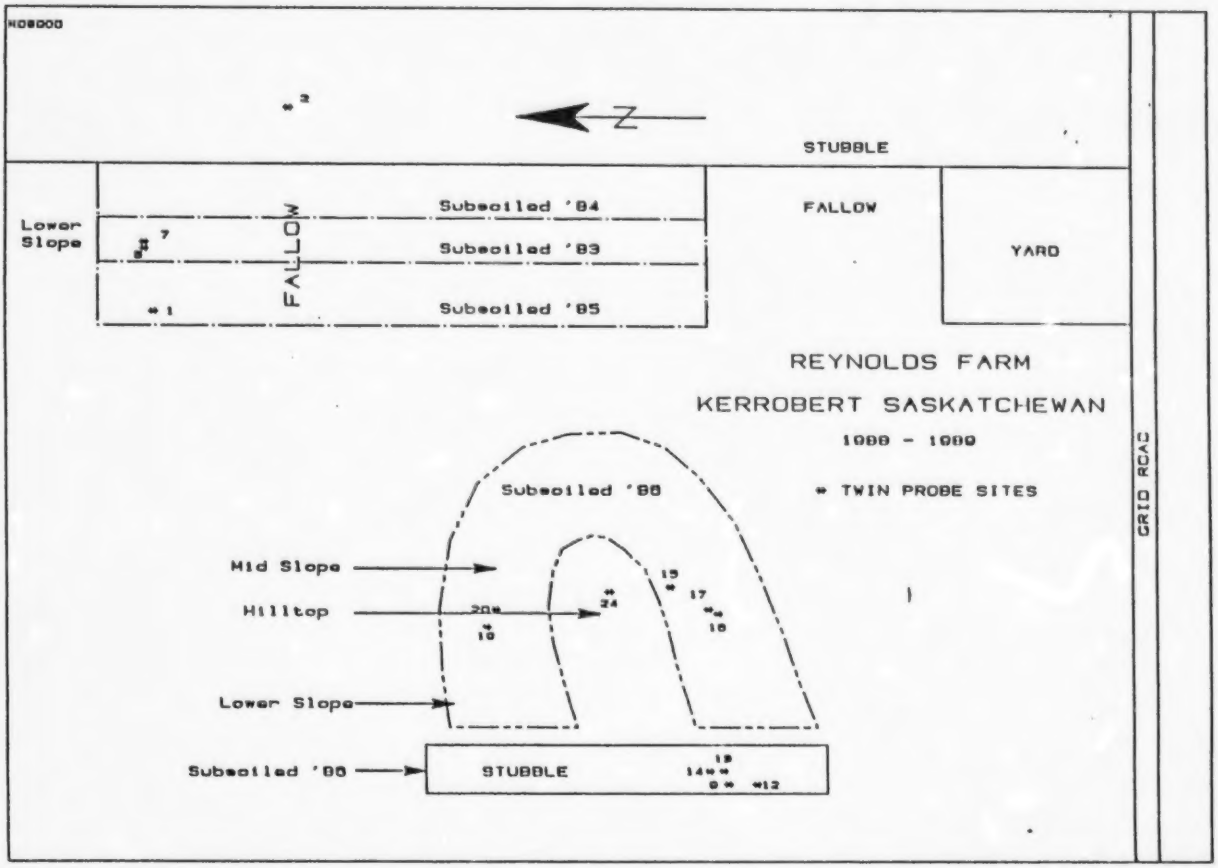

Figure 2. Location of field study sites; West Field, Reynolds Farm, 1988-89.

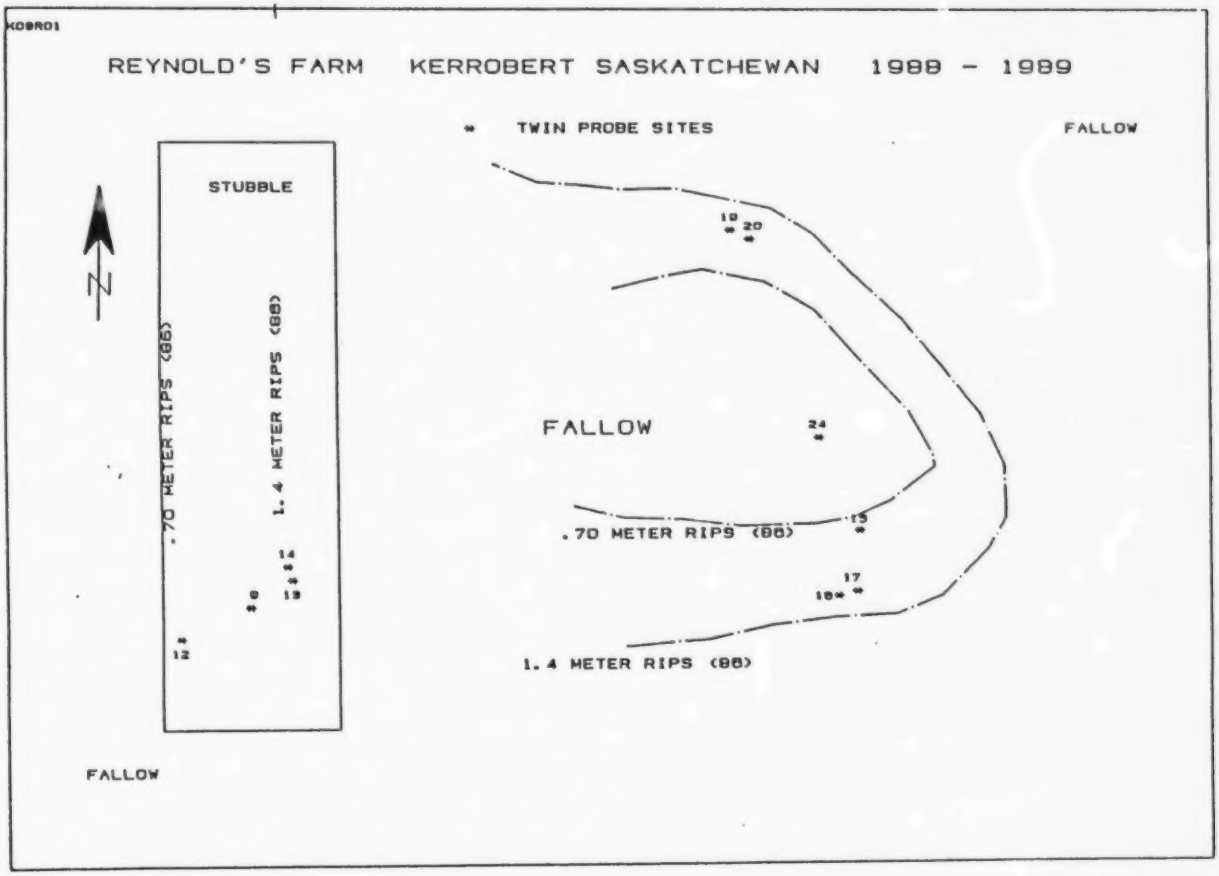

Figure 3. Instrumentation of hill top; West Field, Reynolds Farm, 1988-89.

1988-89 Installations

Two fields have been instrumented on the Reynolds farm at Kerrobert: the "west" field contains subsoiling treatments applied between 1983 and 1986 inclusively; subsoiling on the "east" field was introduced in the fall of 1987.

(a) Reynolds "west" field.

In 1983 and 1984, strips of land (see Fig. 2), approximately 7.5 m wide and 220 m in length, were subsoiled to a depth of 60 cm on a 1.9 m spacing with a "Killefer" plow. In the fall of 1985, two parallel lines adjacent to the 83-84 rips were subsoiled with an "Ebson" plow to a depth of 40 cm on a spacing of 75 cm. In the fall of 1986, approximately 1.9 ha of hilltop land was subsoiled with a "Kello-Built" plow to a depth of approximately 50 cm with rip spaced approximately 70 and 140 cm apart.

As shown in the schematics (see Figs. 2 and 3), the undisturbed and subsoiled areas are instrumented for soil moisture and snowcover depth measurements. Except for a small area (2.5 ha) of the hilltop, which was subsoiled with the Kello-Built plow in 1986, the field is in fallow. The moisture sites will be monitored to establish whether any effects of the subsoiling treatments are retained throughout and following the fallow period. On that part of the hilltop in stubble, low snow fences (40 cm height) are deployed to ensure an accumulation of snow and to allow estimates of the "potential" increases in soil water by infiltration.

Snowfall and snowcover depth and density will also be monitored.

(b) Reynolds "east" field.

In the fall of 1987, two, 3.75 ha plots were subsoiled with a "Hubee" subsoiler to a depth of 50 cm on line spacings of 70 and 90 cm, respectively. A 2.25ha, undisturbed area separating the plots serves as a control. The subsoiled and undisturbed areas were seeded to wheat in the spring of 1988 (2nd year stubble). For the 1988-89 winter season, 18 soil moisture sites have been established, 8 sites in each subsoiled plot and 2 in undisturbed stubble (see Fig. 4). These sites are located in upper and lower sloped positions. As well, soil temperature probes have been installed at sites number 1, 3, 10, and 18.

Because of poor crop growth in 1988, the stand was inadequate to establish effective snow traps by stubble management practices. Hence, a large number of low snow fences (40 cm height have been deployed on the area. These are set in rows approximately 20 m apart and effectively cover about 0.75 ha of each treatment (see Fig. 4). Soil moisture and temperature sites are located inside and outside the fenced areas.

3. Kerrobert (Lyle Wright Farm)

Objectives:

(1) To study the effects of subsoiling on surface runoff from snowmelt.
(2) To obtain information on the longevity of subsoiling treatment effects on meltwater infiltration.

1988-89 Installations

A 2 ha area that drains to a small depression was subsoiled with a Kello-Built plow in the fall of 1986. The depth and spacing of the rips was 50 cm and 140 cm, respectively. The field cover is a uniform stubble during the 1988-89 winter season.

Five soil moisture and snow depth monitoring sites have been installed in the undisturbed (1) and ripped (4) areas (see Fig. 5). In the ripped area, the sites are grouped into upper and lower slope positions.

4a. Swift Current (John Warkentin Farm)

Objectives:

(1) To determine the effects of different subsoiling treatments and snow management on meltwater infiltration, soil water distribution within the crop rooting zone, and continuous wheat yields,

(2) To study the effects of subsoiling and snow management on nitrate leaching and nitrogen mineralization,

(3) To evaluate the economic benefits of snow management and different subsoiling treatments, and

(4) To determine if additional nitrogen is required to make full benefit of conserved water from susoiling and snow management.

All subsoiling treatments with snow management have been established and are: paraplow (1986), chisel plow (1986), paraplow (1987), chisel plow (1987), 'Kello-Built' subsoiler (1987), and non-subsoiled check. Snow trapping was accomplished with strips of standing grain (for maximum trap strip height) spaced 6 m apart.

All subsoiling treatments without snow management (conventional short stubble) have been established and are: chisel plow (1987), 'Kello-Built' subsoiler (1987), and non-subsoiled check.

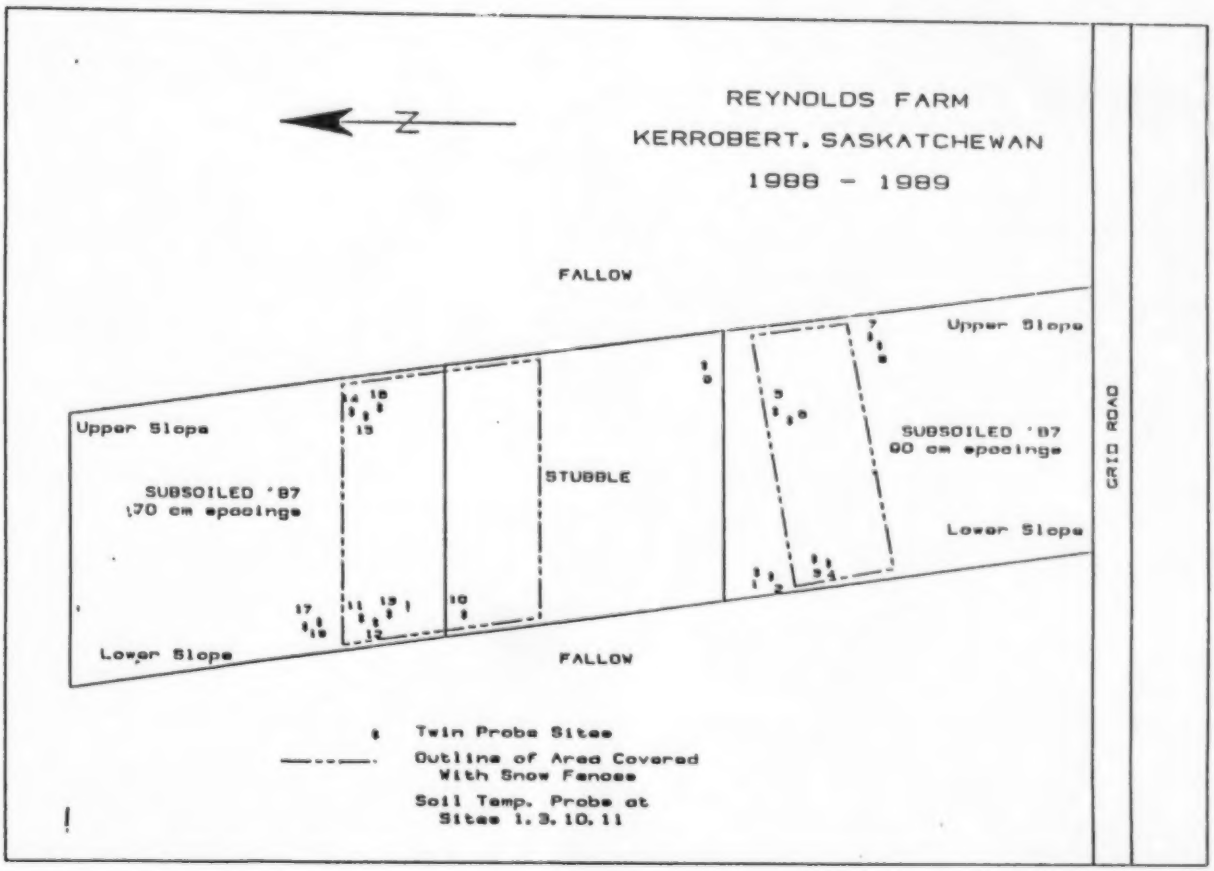

Figure 4. Location of instrument sites; East Field, Reynolds Farm, 1988-89.

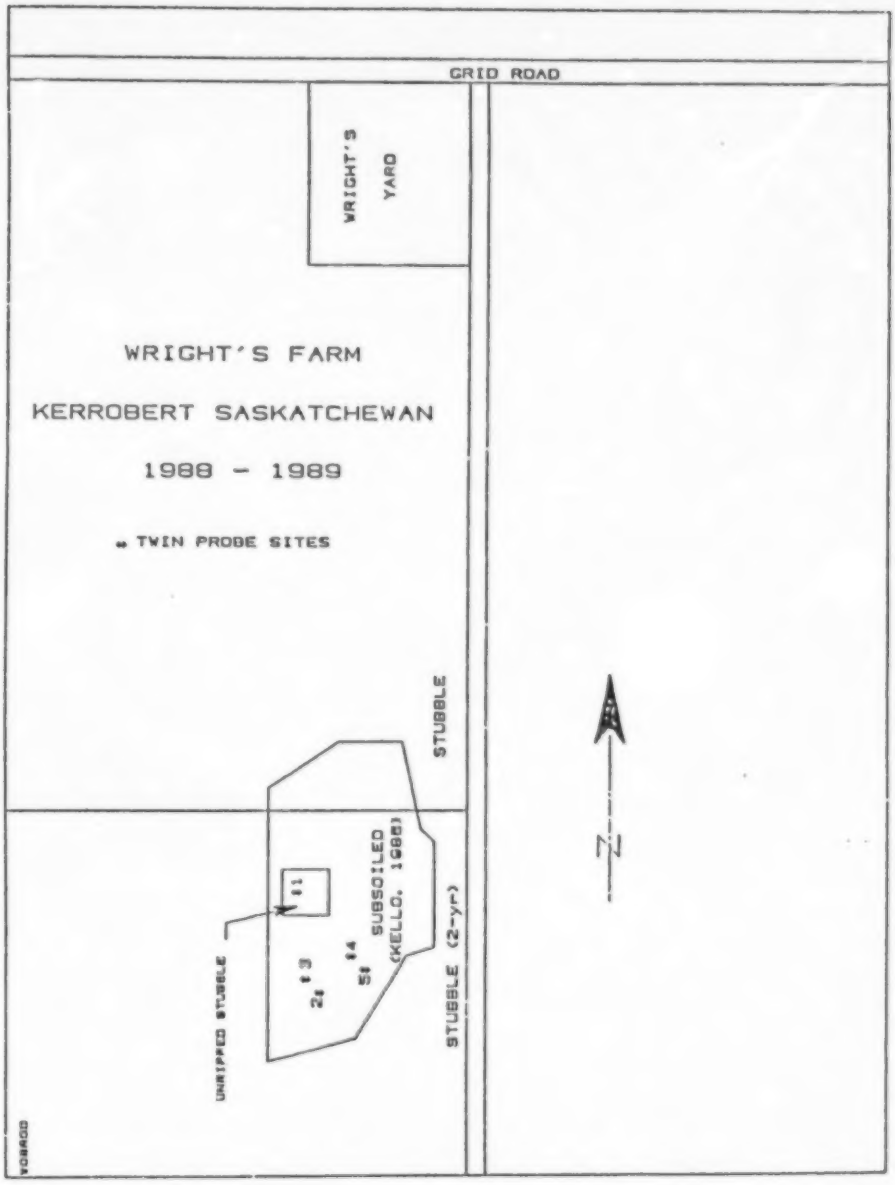

Figure 5. Location of instrument sites; Wright Farm, 1988-89.

Soil infiltration rates were measured in the fall of 1988 and will be measured in late winter when the soil is frozen. Soil strength for each treatment were measured with a cone penetrometer.

A separate, less intensively monitored, experiment was added in November, 1988 to compare the performance of the prototype 'Big Ben Disc' subsoiler (28 cm deep, 52 cm spacing) to the chisel plow (28 cm deep, 55 cm spacing), the paraplow (33 cm deep, 50 cm spacing), and the non-subsoiled check.

4b. Swift Current (John Warkentin farm)

Objectives:

(1) To evaluate the effects of several subsoiling treatments on meltwater infiltration and wheat yields for different slope positions.

(2) To evaluate the economic benefits of subsoiling and snow management for rolling land.

The three subsoiling treatments from 1987 are: 'Hubee' subsoiler, and the new model 'Kello-Built' subsoiler.

Snow management was accomplished by leaving a strip of standing grain (to maximize height of barrier) on a six meter spacing perpendicular to the slope. Low (10-20 cm high) dikes were constructed between the plots. Soil strength was measured with a cone penetrometer. Soil infiltration rates will be measured in late winter when the soil is frozen.

5. Davidson (Gary Schmiedge Farm)

Objectives:

(1) Determine the potential for enhancing groundwater supply in a shallow aquifer overlain by course textured soils.

Snow fences have been installed in an alfalfa field site which has been instrumented with nine piezometers, four gamma sites, two air and soil temperature recording sensors and Fischer Porter rain and snow gauges. Initial field monitoring has been conducted and routine measurements are scheduled similar to the other study sites.

General Data Collection Procedures

All soil moisture and temperature sites at Saskatoon, Kerrobert and Swift Current were monitored at or near the onset of soil freezing. These observations have been tabulated and checked for quality control.

The sites will be monitored on a regular basis throughout the winter. Measurements will be obtained prior to and as soon as possible after the completion of melt in order to determine the infiltration amounts.

A detailed snow survey, including measurements of snow depth and density, will be carried out on each field in order to establish the snowcover water equivalent. Nipher gauges have been installed at each location to provide a measure of snowfall water equivalent.

Analytical Studies

In addition to the field program, ongoing analytical investigations are directed towards the development of predictive, operational models for describing: (a) the wind transport of snow, (b) snowmelt infiltration into frozen uncracked, cracked and subsoiled soils, and (c) evaporation during "Postmelt", the period from the end snowcover ablation up to the time of seeding of cereal grains. A brief outline of these studies and the manner the results contribute to the "overall" program objectives is given below.

Wind Transport of Snow

The study of the snow transport phenomenon is an attempt to quantify at various locations in the Prairie region, the relative amounts of snow which move in saltation and suspension and the amout of snow water lost by sublimation during wind transport. This information is needed: (a) to assess the potential of (stubble) management practices for increasing the depth of snowcover accumulation and reducing the water loss in different parts of the Province and (b) to establish design criteria (optimum height) width, spacing, and orientation of barriers) for a specific practice in order to obtain maximum "trapping efficiency".

The investigation makes use of the "Prairie Blowing Snow Model" (PBSM) developed by the Division of Hydrology. The PBSM estimates the horizontal mass flux of blowing snow in saltation and suspension, the blowing snow sublimation rate, and the snow surface erosion rate over surfaces with different roughnesses (vegetative cover and land use) and fetch distances. It uses climatological observations of wind speed, air temperature and humidity, precipitation, the presence of snow, and vegetation and terrain information. With parameter estimation (length, roughness, snowcover and other) established by upwind "fetch"

conditions the system gives the potential snow flux entering a field from different directions. Fluxes calculated from 6 years of climatological data at 20 stations throughout the prairies and assumed "natural" fetch conditions are currently being analyzed. In addition, work is proceeding on the development of procedures to distribute a "calculated flux" over a field so as to study the effects of different stubble management treatments on the snowcover accumulation patterns. The work, combined with research directed towards the assessment, validation and verification of model performance, will continue in the next year.

Snowmelt Infiltration into Frozen Soils

An "existing" model describing snowmelt infiltration into completely frozen, uncracked soils as a function of snow water equivalent (SWE) and soil moisture/ice content is continually updated as field data are acquired. A specific aspect of the investigation is centered on parameter adjustments that need be applied to the model in order to account for the effects of soil salinity on infiltration, such as encountered with the slightly solenetzic, glacial tills at Kerrobert.

Another phase of the study is directed to the refinement and verification of a "first-generation" model describing meltwater infiltration into "subsoiled" soils. This model gives the amount of snowmelt infiltration as a function of SWE, and spacing of rips. It quantifies the interaction between rip spacing and infiltration efficiency and it can be used to estimate the optimum spacings for different depths of accumulated snowcover.

Both of the preceding studies make use of data collected in the field program.

Evaporation During Postmelt

Soil moisture changes monitored during the period from the end of snowmelt up to the time of seeding of annual cereal crops (Postmelt) show that the major loss of water from the crop root zone is due to evaporation. Any procedure which is used to predict the effects by subsoiling or some other practice whose primary purpose is to enhance meltwater infiltration and soil water availability at seeding must consider this loss. Two factors inhibit direct application of "existing" operational models for estimating evaporation. They are: (a) most models do not account for the amount of energy used to "thaw" a frozen soil, which otherwise would be used for evaporation, and (b) the lack of data on evaporation losses from subsoiled soils during "Postmelt".

An evaporation model for non-saturated soils which is based on a combined energy balance and aerodynamic approach and considers the "net energy" available for evaporation has been developed and assessed. The model uses the relative evaporation,

the ratio of actual to potential evaporation, whose magnitude is calculated from atmospheric and soil parameters. Preliminary examination of "predicted" and "measured" soil moisture changes during Postmelt suggest the relationship is single valued and independent of land use, provided the ground heat flux, surface albedo, surface roughness, and the vegetation displacement height are properly accounted for in the calculations of the different energy terms. Future trials will use archived data and observations from the field program to verify and calibrate the model over a wider range of soil moisture and surface conditions.

ACKNOWLEDGEMENTS

The authors of this report would like to acknowledge the financial support received from the Saskatchewan/Canada Economic Development Assistance (ERDA) Agreement that made this study possible. The co-operation of D. Sutherland of Richlea, R. Reynolds and L. Wright of Kerrobert and J. Warkentin of Swift Current, owners of land on which the studies were implemented is gratefully appreciated. The assistance of L. Gramiak, J. Pratt and B. Simm of Saskatchewan Agriculture who had assisted in organizing farm meetings to extend information gained from the project and in day to day concerns in project operation. The technical support of Dan Ulrich and Don Reimer of Agriculture Canada at Swift Current, Del Bayne and Raoul Granger of the University of Saskatchewan Hydrology Division and Kelly Best, Keith Wallace and Ross Mackay of NHRI who worked diligently in adverse weather conditions to monitor the sites is gratefully appreciated.

A thanks to Kello-Built Industries and the Hubee Manufacturing Equip. Inc, for making their equipment available for this study . Also thanks to the Hoechst Canada for making chemicals available for this study.

TECHNICAL STAFF EMPLOYED BY THE PROJECT

	% TIME
Del Bayne - U of S Saskatoon	100
Pat Landine - U of S Saskatoon	40
Dan Ulrich - Swift Current	100

NHRI TECHNICAL STAFF ASSIGNED TO THE PROJECT

Kelly Best	30
Keith Wallace	10
Ross Mackay (Summer Student)	30

PROFESSIONAL STAFF ASSOCIATED WITH THE PROJECT

D.M. Gray - University of Saskatchewan

B. McConkie - Agric. Canada, Swift Current

W. Nicholaichuk - NHRI

R. Granger - University of Saskatchewan

B. Simm - Saskatchewan Agriculture

EXTENSION ACTIVITIES

As reported in the February 1988 Annual Report, principals associated with the project made presentations to a series of Saskatchewan Agriculture and PFRA organized farm meetings on soil conservation that were held at Kindersley, Rosetown, Davidson, Bruno, Biggar, Outlook , Eston and Prelate. Presentations were made using slide and video materials that described in detail subsoiling operations and the results of the study to date.

Plans have been initiated in co-operation with Saskatchewan Agriculture to participate in another series of farm meetings in the 1988-89 winter season. A factsheet on 'moisture management' is being prepared in co-operation with Professor Mike Grevers for the Tillage Sub-Committee.